The Etiology of Empyema in Children:

An Experimental and Clinical Study.

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The first aspiration and exploratory puncture of the pleural cavity was performed by Bowditch, the American physiologist, and from this bold innovation upon the former methods in vogue may be traced our decided advances in the treatment and proper understanding clinically of the pathological conditions of the pleura. In his address before the Tenth International Medical Congress, Sir Joseph Lister in speaking upon empyema said: "There are few more beautiful things in antiseptic surgery, as contrasted with the results of former practice, than to see the abundant purulent contents of the pleural cavity give place at once to a serous effusion, rapidly diminishing from day to day." Surgery has therefore been in advance of pathology, and it was reserved to a very recent period for some enlightenment upon the nature of empyema and pleurisy to appear, and supplement the surgical advance in this department of medical learning.

This advance has been made through the avenues of modern bacteriological methods. I am certain that with the light thus thrown upon the nature of empyema in the adult, the diagnosis and understanding of this disease will have received incalculable aid, and the future treatment in both surgical and medical directions will be based upon more certain data than hitherto. I think we have passed that stage which justifies the general grouping of all suppurating pleural processes as empyema without modifying this term so as to point out at once the etiology. If the above is true of the adult, we would naturally expect the same phase of this question when applied to children. Though we have many of us taken for granted that what was true of the adult might be equally so of the infant and child, it has been the object of the author of this paper to make such an inquiry in exact channels, as had been done by others concerning the adult. The literature upon the etiology of empyema in the adult is not so very extensive, if we regard those works only which are really systematic, and therefore of satisfactory merit. The first complete contribution, an attempt to formulate the different varieties of

empyema from a bacteriological standpoint, was that of A. Fränkel.[1] This paper contains the result of a series of studies extending back as far as 1886. The author divides empyema into the following groups:

Those in which the etiology is still a matter of speculation. In these we cannot point to anything positive, because both the clinical history and bacterioscopic examination of the purulent exudate give no support to any definite theory. In these cases the exudate upon examination fails to yield anything but a microörganism which is found in processes of diverse nature in the body. From the chain-coccus, or streptococcus pyogenes, we could with much justice presuppose an antecedent pneumonia; we might follow this chain-coccus in its migrations through the lymph-channels of the pulmonary pleura; but, on the other hand, there are authors who, like Fraentzel, believe in the occurrence of a "pleuritis acutissima." Unfortunately, this disease described by Fraentzel is of most rare occurrence and doubtful etiology. Traumatism or cold have been invoked in these cases as predisposing causes which allow such microörganisms as streptococci to act upon the economy by reducing its resistant vitality. We must here presuppose the continued presence of microörganisms in the subpleural tissue, even in subjects who clinically cannot be said to be suffering from any active disease. In the course of investigations upon empyema, the question has arisen whether an effusion into the pleural cavity might from the very onset be purulent; those of experience answer in the affirmative. In children especially we are apt to think that an effusion is serous, or rather non-purulent, if the exploratory needle gives what to the eye appears a clear, not turbid fluid. The inquiries into the pathology of these cases show that those acute cases showing a serous exudate which subsequently becomes purulent are really at the time purulent (from the beginning, in the most modern acceptation). To return to our first premise, though Weichselbaum has distinctly shown, in lobar and lobular pneumonia of the adult, that the streptococcus pyogenes and also the staphylococcus are present as so-called mixed infections, yet when we come to consider the exclusive presence in the exudate of empyema of these microörganisms there is a gap to be explained which, as far as we know, has not yet been clearly elucidated.

In another group of cases Fränkel found the exclusive presence of the pneumococcus or diplococcus pneumoniæ; this microörganism was found in pure culture in the exudate derived from the pleural cavity. The pus was of a thick, adhesive character, and the cases of this group are classed as post-pneumonic or concomitant with pneumonia (lobar pneumonia). Fränkel maintains that in these cases suppuration is

[1] "Ueber die bakterioscopische Untersuchung eitrige Ergüsse," Charité Annalen, 1888, p. 147.

maintained in the presence of a closed pleural cavity by the presence of bloodvessels with the existence of a different nutritive medium than in the artificial structures.

The third group of empyemas are those whose nature is tubercular. In all these cases he could not establish the presence of tubercle bacilli, for some baffled all the aids to diagnosis of this microörganism, both in plain stain, culture, and experiment. Fränkel has come to the conclusion that the absence of any result as far as stain and culture were concerned, in the study of exudates, pointed very strongly toward a tubercular element in the etiology of the empyema. Garré and Rosenbach in experimenting with the pus of cold abscesses had a similar result. Fränkel found tubercle bacilli by staining methods in only one case of four investigated; in the others the results were negative.

There is, according to this author, a fourth group of cases, in which we can find a focus of infection situated outside of the pleural cavity. He had two such cases, in both of which the chain-coccus was found, and one of which followed a perforating peritonitis, the other a retro-pharyngeal abscess. The conclusions of this author relating to empyemas are that the presence of the chain-coccus or streptococci, or staphylococcus pyogenes is not diagnostic. The presence of the diplococcus pneumoniæ points to a preceding pneumonia or complicating pneumonia. An exudate which fails to yield any positive result either by stain or culture is in all probability tubercular.

Weichselbaum's name is also indissolubly connected with much good work in this field. He examined eleven cases of pleuritis.[1] Two of these cases were of a purulent and one of a sero-purulent nature, the remaining eight were serous. In the empyemas he found the streptococcus pneumoniæ, or what we may call streptococcus pyogenes, and in another case, which proved fatal, the diplococcus pneumoniæ was found. About this time, Fränkel published[2] two cases of empyema following pneumonia, in which he found the diplococcus pneumoniæ.

The above historical review would be incomplete without the mention of the important work of Ehrlich in the study of pleurisies.[3] He investigated by staining methods the bacterial character of fluids obtained from the pleural cavity in forty-five cases of pleurisy; of these, nine were tubercular, twenty simple pleurisy, six carcinomatous, and nine empyemas of various kinds. Of nine tubercular cases in which the sputa of the patients contained tubercle bacilli this microörganism was found in only two. The negative result in the remaining seven does not by any means prove the absence of tuberculosis of the pleura.

[1] "Ueber die Etiologie der acuten Lungen- und Rippenfellentzündungen," Medizin. Jahrbücher, 1886, Heft 8, p. 483.

[2] Zeitschr. für klin. Med., 1886.

[3] Beiträge zur Ætiologie pleurit. Ergüsse," Charité Annalen, 1882, p. 207.

The work upon empyema in children is, in contrast to what has been recorded of the adult, limited to a few scattered notices in the literature. The most important is found in the work of Rosenbach, who examined the exudate of a case of empyema and found the micrococcus tenuis (pyogenes), or what is now thought might have been the diplococcus pneumoniæ, present.

The recent articles of Von Ziemssen ("Vorträge") and Liebermeister are simple literary *résumés* upon the subject.

ORIGINAL INVESTIGATION.—My own work upon empyema was framed upon the lines outlined in the above review. An attempt was made to see how far the results in children, from a bacteriological standpoint, would correspond to those attained in the adult, or whether they would differ. In June of last year, I reported in brief my results in twelve cases; there are three additional cases to report, in one of which at least some interesting points will arise. The work done was upon material which at the time, for the most part, was in a hospital ward, evidently an advantage. The mode of bacterial study was in accord with what is practised by the Koch school of investigators. Some of my cases were taken from my dispensary class; others from private practice or those of my friends. It being established both from the clinical history and physical signs that there was a probable existence of empyema, the chest of the patient was carefully cleansed with soap and water, and then with sublimate; the excess of antiseptic fluid having been removed, a clean and sterilized hypodermic needle was introduced into the chest. To avoid contamination, a new syringe was used for each case, for it is very difficult to be certain as to the cleanliness of a syringe which has been once used for pus. The ordinary hypodermic syringe was used after being cleansed with sublimate, alcohol and ether, and then sterilized distilled water. The needle was sterilized with heat in the dry oven at a temperature of 160 to 170° C., kept in a sterile test-tube and only put upon the syringe at the last moment. A specimen of the contents of the pleural cavity once withdrawn was placed in an empty sterilized test-tube and taken as soon as possible to the laboratory and examined. The examination included not only the study of the gross specimen, the preparation of crude pus upon cover-glasses in the ordinary way, and then stainings of the crude pus, but plates and cultures were made upon media to establish the bacteriological character of the fluids withdrawn. The media used for culture experiments were bouillons, gelatin, glycerin agar, agar-agar, Weichselbaum's agar;[1] blood-serum and potato plates were first made to obtain colonies, as also test-tubes prepared by rubbing the fluid to be examined upon the obliquely solidified media, as

[1] By Weichselbaum's agar is meant the agar recommended by this author, containing 1½ per cent. of agar, peptone, and grape sugar, with ½ per cent. of salt.

agar (Weichselbaum); and pure cultures were also obtained from the plates, and if growth occurred in the tubes, plates were made to test the purity of the growths. Re-inoculations upon other media were made; when pure cultures were obtained, these were injected into animals for experiment. The animals used were rabbits, guinea-pigs, rats and mice. The most uniform results were attained from the rabbit experiments. The microörganisms were taken from a pure culture from an agar tube and suspended in sterilized distilled water, or, mostly, a pure bouillon culture was directly injected. The injections upon animals and autopsies were performed with the ordinary precautions followed in the bacteriological laboratory.

The characters of the crude pus withdrawn from the various cases are of interest when considered in relation to one series of cases, namely, those in which the diplococcus pneumoniæ of Fränkel and Weichselbaum was present. In some of this set of cases, the pus seemed of a rather glutinous adhesive nature; it would adhere to the sides of the test-tube when the same was inclined; this pus was either creamy-white in color, or greenish, or greenish-yellow. In these cases the chest was sometimes filled with enormous clots of fibrin, which were expelled from the opening made by resection of the rib. The pus also in some cases separated in a serous and opaque greenish layer upon standing; in other cases, as in greenish pus, the same had no adhesiveness. I mention these facts, because Fränkel has pointed out the adhesive or glutinous nature of the pus withdrawn from the adult cases, and the same characters in similar cases were easily established in children. In none was a fœtid odor perceptible, either in the pus derived from the cases in which the diplococcus pneumoniæ was present, or in those in which the streptococcus or staphylococcus pyogenes was found. Primarily, none in the series I have examined were fetid. In two cases the pus became fetid after the chest had been opened, and these cases, both of diverse nature, I will attempt to explain later. In all cases the crude pus was spread upon cover-glasses and stains made both for tubercle bacilli, diplococcus pneumoniæ, and other microörganisms; care was taken to follow out a routine in each case by which tubercle bacilli (Ehrlich's stain) could be excluded. In those cases in which the capsule cocci were found by simple stains with methyl or gentian-violet, the resistance to Gram's discolorization was tested.

For the sake of simplicity, we can formulate results in the following manner: In the pus of the fourteen recorded cases, I found the following microörganisms:

The streptococcus pyogenes.

The staphylococcus pyogenes aureus.

The diplococcus pneumoniæ (Fränkel and Weichselbaum).

The tubercle bacillus (Koch).

In few of the cases did I find these microörganisms associated, but usually existing alone in a specimen of pus. The tubercle bacilli were found associated with the streptococcus, as I shall later explain. It was certainly striking, at least in my series of cases, that the organism found existed in the fluid withdrawn from the chest in so-called pure state. The pus was really equivalent to a pure culture of one of the microorganisms. It would be tiresome and of little value to go into detailed description of the staphylococcus pyogenes aureus and streptococcus pyogenes found in my cases, and it will suffice to say that they are in culture media, and when injected experimentally acted in a way exactly corresponding to all that is known of these microörganisms.

The Diplococcus Pneumoniæ (Fränkel and Weichselbaum).—When the pus from an empyema is rubbed upon the surface of an obliquely solidified tube of agar-agar of Weichselbaum, and placed in a temperature of 35° to 37° C., there appears within about six hours a thin, almost imperceptible coating very much like dew on the surface of the agar; within twenty-four hours this is more marked, though it is still very delicate and veil-like, and does not seem to grow vigorously. In the depth of the agar, if the same has been inoculated, there is a delicate veil-like reticulum. If such a surface culture be examined after successive re-inoculations, it is made up of very minute transparent punctate areas or colonies; as a whole, the growth does not attract the eye by any particular hue. If a puncture culture, as it is called, is made on agar, the area around the top of the puncture is very minute and scarcely perceptible. Colonies from pus sown upon agar-agar plates are at first so small as to be discovered only by the aid of a lens; they never attain a very large size, and are situated in the depth of the medium, and inoculated by means of the platinum point only with the greatest difficulty. The reason of this seems to be that the microörganism is so delicate that not enough adheres to the platinum tip to favor growth in the test-tube. The colonies after forty-eight hours are round, granular, with a darker centre, some of them, than periphery; they are of a transparent very light grayish tint or straw color by transmitted light; when the plate with colonies is held against a dark background, the reflected impression is that the colonies have a whitish tint. Unless this microörganism is transferred very early during the first few days to other tubes, it stops at a certain point and ceases growing—in other words, it may be lost. The colonies, especially in four or five days, begin to die out, becoming fainter to the lens and taking on the color more and more of the surrounding agar. The above applies to the diplococcus in pure culture derived from pleuritic fluid. After inoculation into animals, the growth, though the same in all essentials, seems to have attained a greater vigor, though even here, if not saved by repeated re-inoculations upon media, it dies out quickly.

Gelatin.—In gelatin, at the ordinary room temperature, there is no growth; at the temperature of 23° or 24° C. there is a very delicate growth which never becomes vigorous; along the puncture there is a granular minute beaded structure, but of the greatest delicacy, and the gelatin is not fluidified.

Blood-serum.—The growth here is much the same as on agar-agar of Weichselbaum, though the colonies making up the surface culture may be said to be more grayish in tint, or slightly more perceptible than upon the agar.

Bouillon.—Here there is first a general clouding of the medium, and then a deposit of flocculi along the sides of the tube, and finally a small deposit in the bottom of the test-tube, leaving the fluid or bouillon above finally clear. When shaken, there is great turbidity and abundance of fine flocculi.

Potato.—There is here no perceptible growth.

Ordinary agar.—It is certainly a waste of energy to attempt to cultivate the diplococcus successfully upon ordinary agar, for failure will be the most frequent reward. In other words, much valuable time has been wasted by others as by myself in making such attempts. The least variation in moisture or reaction will compromise the growth, so that I have worked mostly with the agar-agar of Weichselbaum, rather than with that made up by the old formula.

Glycerin agar—six per cent. to eight per cent.—did not seem to present any advantages. The growth was very slow and difficult of re-inoculation, and capricious.

Stainings.—The crude pus shows us the diplococcus with its capsule. I have had no difficulty in establishing the presence of the capsule coccus by means of the simple methyl-violet or gentian-violet and aniline water stain, taking care not to over-stain. If the specimen should have been over-stained, it can be easily decolorized (but this very lightly) with dilute alcohol. The pure culture shows the diplococcus from agar very beautifully, as oval or round diplococcus forms of apparently the size seen in the crude specimen without any capsule; the diplococci may be single or in chains of two or three pairs. By the Gram stain there are also seen both in the crude pus and crude culture some of the peculiar lancet-shaped forms; while I could find here and there a beautiful lancet form, there were many which upon analysis appeared peculiarly crenated, perhaps due to either unequal decolorization or overheating. The capsules in the crude specimens are decolorized by the Gram method, though the light decolorized zone of their presence may be seen by strong and favorable illumination in some cases.

The Staphylococcus Pyogenes Aureus which was met in these empyema cases could in no way be distinguished from the staphylococcus which I separated and cultivated for comparison from the ordi-

nary furuncle of the skin. It reacted in the same manner in the various culture media. In the gelatin it grew at the ordinary room temperature along the puncture and had the same yellow-gray or straw-color beaded look. The gelatin, after the third or fourth day, became liquefied; this began at the top and proceeded along the puncture in length and breadth. After a time the liquefied gelatin showed the finely granular suspended colonies, and the sediment at the bottom of the liquefied gelatin took on the same orange-yellow color.

Agar-agar.—Upon obliquely solidified agar there was at a raised temperature a very vigorous growth on the surface, and in the depth, which, at first whitish-yellow, after a time assumed a rich orange-yellow tint; the surface of the growth was moist, and its edges sinuous and raised very perceptibly above the surface.

Potato.—The well-known orange-yellow moist growth was perceptible within twenty-four hours, increasing in vigor and luxuriance; it was at first golden-yellow, then deeper orange-yellow, having the peculiar odor of the ordinary culture of staphylococcus.

THE STREPTOCOCCUS which I have isolated from cases of empyema reacts in media exactly similarly to the ordinary streptococcus pyogenes. In agar-agar plates the colonies remain small but some large, some irregularly round, others oval of a brownish-olive tint and granular appearance. In punctures the finely beaded dots and zone surrounding the top of the puncture exhibit no tendency to spread to any extent; on the surface of obliquely solidified agar a pearly-gray growth is seen (Weichselbaum's agar) made up of drop-like masses in the depth; the same beaded appearance in either a band or puncture that is seen in ordinary agar.

Gelatin.—Small finely granular colonies, at first straw-tint and sharply round, later more brownish with an olive tendency. At border, through gelatin, they appear straw-color, on surface of gelatin they have a distinct cupola (raised); they grow in depths also. In punctures, finely granular, no liquefaction of gelatin.

Bouillon.—In twenty-four hours we have a cloudy appearance, and deposit of masses on sides of test-tube, finely granular in the centre. Stainings show exquisite chains.

Potato.—Nothing characteristic or perceptible.

EXPERIMENTAL.—The experimental part of my work was laid out upon very simple lines, and is intended merely to add confirmatory evidence upon the nature of the microörganisms which I have isolated from the various cases of empyema reported. The results attained, it will be seen, are almost identical with those obtained by other observers (Fränkel and Weichselbaum).

My method consisted first, in isolating microörganisms so as to obtain a pure culture of each variety, and then injecting this pure culture into the animal to be experimented upon. The animals used were mostly

rabbits, but a few scattering experiments were performed with guinea-pigs, rats, and mice. The injections were made with sterilized hypodermic needles underneath the skin and into the pleural cavity or lung. There were no inhalation experiments. A pure culture of any micro-organism having been injected into the animal, the same was observed, and if the animal survived, it was, after a sufficient period had elapsed, killed and pathological effects noted. If the animal died from the effects, the blood, and the pleuritic, pericardial and peritoneal fluids were examined, and the nature of the contained microörganisms established in exactly the same manner as had been done with the original pus obtained from the empyema. Re-injections of these pure cultures from animals were made, as also injection of pleuritic and peritoneal fluids from animal to animal. Pus in crude state from empyemas was also injected into animals, and the microörganisms cultivated from the blood and fluids of such animals.

The most interesting series of experiments in their results were those performed with the pure cultures of the diplococcus pneumoniæ. In every case the isolated microörganism was injected into a set of animals, and the results have been noted. After the first effects of the injection had passed off (chest injections into pleura), the animal in some cases seemed to be as well as ever, but after a few days, varying in different cases, the animals in most cases died. Death was, as a rule, preceded by a short period of dyspnœa, or again the animals may have appeared ill through the whole experimental life. The autopsies revealed in most cases pleurisy single or double, even though injection was made into one side of the chest. The lungs in no case were the seat of complete hepatization (pneumonia) lobar in distribution; but in rabbits 1, 3, 6, 9, and 11 there was a condition of the lung not dissimilar to an engorgement in areas to smaller or greater extent. In rabbit 6 this approached closest the type of hepatization in the upper lobe of the left lung. Pericarditis was present in most and also very marked peritonitis. Care was in all cases exerted to inject the fluid containing the microörganism just beneath the rib into the pleural space, though it was often impossible to say that it had not penetrated the lung; at least care was taken that it should not do so.

In most of the cases the spleen was enlarged to palpably twice or thrice its original size. Cultures made of the blood and pleuritic or pericardial fluids of such animals also yielded a uniformly certain growth of a diplococcus which in every way and reaction corresponded to the diplococcus pneumoniæ of Fränkel and Weichselbaum. Its growth was at first quite vigorous on the Weichselbaum agar, but it died out and was soon lost if not re-inoculated, just as the original pure culture obtained from the empyema pus. Animals injected with the pleuritic or peritoneal fluid of other animals that had died of

injection of pneumococcus also died certainly and even rapidly. The lung and spleen fluids (obtained by expression) with cover-glass stain also showed myriads of these diplococci. By the injection of pure cultures of diplococcus underneath the skin, the results were not so certain, though in some the animals died with the above features. The pus from empyemas known to contain nothing but diplococcus pneumoniæ also killed the animals with unfailing certainty; cultures made from these animals revealed the diplococcus only, and injections of peritoneal fluids from these animals into others proved fatal with results showing pneumonia, pleuritis, pericarditis, and peritonitis, and in all the fluids of such animals, inclusive of the blood, the diplococcus was found. In some cases the animals would seem to have had vitality enough to have resisted this organism, and completely recovered from the effects of their injections and consequent inflammatory disturbances. Such animals were killed after a sufficient period had elapsed, and in most cases there could be seen adhesions of the pulmonary to the costal pleura, and adhesions of the pericardial surfaces. Some guinea-pigs injected gave results much the same as those seen in rabbits. In other cases the animals seemed to have successfully resisted the effects of the micro-organisms, for upon autopsy nothing was revealed that could be traced to any pathological process.

Experiments with the streptococcus which was isolated from the pus of the empyemas recorded in this paper, and which appears to be identical with the streptococcus pyogenes, though positive in some features were yet not so distinctive. The results seemed to vary, for while in some cases streptococci did not prove fatal, in another the effects seemed most virulent and rapidly lethal. In some, injection of streptococci into rabbits had no effect, the animals survived, and being killed after weeks had elapsed, absolutely nothing abnormal was found. In other cases streptococci (from the same empyema) caused marked disturbances; the animal appeared quite ill, but recovered and was for weeks apparently in good health; when killed, a few pleuritic adhesions only were found.

In other cases, an injection of a pure bouillon culture of streptococci, notably in rabbit 15, taken from Case XI., caused the death of the animal in two days, and autopsy revealed nothing but an enormous spleen (the largest I have seen in my experiments) with kidneys palpably swollen; cultures of the blood revealed streptococci. Thus, in this case, we have the symptoms of a pure septic effect, a septicæmia without inflammatory lesions. Again, this same bouillon culture, which was pure in every way and repeatedly tested as to purity by plate methods, was injected at the same time into another animal in the same amounts, though not in the same manner, and there resulted the unusually virulent effects seen in rabbit 16, in which small metastatic abscesses appeared in

different organs of the body, and general jaundice. The spleen also was notably enlarged. The results, though corresponding in certain ways, do not give anything not characteristic of streptococci isolated from other inflammatory processes in the body, and the experiments upon rabbits 15 and 16 agree closely with what is recorded of experiments made with streptococci pyogenes isolated from cases of pyæmia, and notably that of the kind recorded by Baumgarten.

I did not make any experiments with staphylococci isolated in my cases, the reactions of the microörganisms being so familiar in every laboratory. It appeared to me sufficient to establish its biological identity.

The experiments with the pus obtained from the cases of tuberculous empyema were negative. The pus was contaminated at first with streptococcus pyogenes and later with putrefactive microörganisms, and this clouded the reliability of the experiments. Injections into the eyes and pleuræ of animals gave no results that were of scientific value.

Experiments upon Animals.

Rabbits, diplococcus pneumoniæ.

1. Medium-sized, white rabbit, injected in pleural cavity, with a pure culture in bouillon of the diplococcus pneumoniæ; died in eighteen hours.

Autopsy.—Rigor mortis marked; chest on both sides showed pleurisy of a sero-fibrinous character; fibrin of a greenish-yellow tint; serum more abundant in left chest. Pericardium: pericarditis, with slight amount of fibrin. Peritoneum: a slightly increased serum; no fibrin; no evidence of inflammation; Blood gave upon culture and stain diplococcus pneumoniæ (pure). Pleuritic fluid, diplococcus pneumoniæ pure culture.

2. Black rabbit (small). Inoculated March 17th; killed by medulla while dying, March 21st. Injected pure culture diplococcus pneumoniæ in chest.

Autopsy.—Sero-fibrinous pleurisy, double sero-fibrinous pericarditis. Peritonitis, sero-fibrinous exudate. Spleen large and swollen. Blood and pericardial fluid pure culture diplococcus pneumoniæ.

3 .Small white rabbit; injected about ten minims bouillon culture in chest of diplococcus, March 18th.

Autopsy, March 22.—Beginning rigor mortis. Slight pleuritis; very little serum and fibrin in pleuritic cavity. Sero-fibrinous exudate in peritoneal cavity (peritonitis). Spleen not very large. Blood gave pure culture diplococcus in agar and bouillon; no growth in gelatin and found also by stain. Lung juice crude cover-glass gave exquisite capsule diplococci.

4. Rabbit, medium sized, injected with pure bouillon culture diplococcus pneumoniæ; died instantly; failure of injection.

5. Rabbit, medium sized; injected in chest same as 4; died on the fourth day.

Autopsy.—Pleuritis double sero-fibrinous; very severe. Pericarditis sero-fibrinous, pericarditis marked. Spleen large and soft. No peritonitis; no meningitis. Specimens of blood, pleuritic and pericardial fluid inoculated on agar, gelatin, bouillon, etc.; reaction by stain and culture of diplococccus pneumoniæ.

6. Rabbit, medium size, injected in chest with pure culture of diplococcus pneumoniæ; died in six days.

Autopsy.—Double sero-fibrinous pleurisy. Pericarditis sero-fibrinous. Peritonitis sero-fibrinous. Spleen large. Cultures made from blood and pericardial fluid; diplococcus pneumoniæ.

7. Rabbit, medium size, injected subcutaneously with pure culture of diplococcus pneumoniæ; no result.

8. Rabbit, black and white spotted, medium size; injected in chest with five minims of empyema pus in which diplococci pneumoniæ existed; animal died in thirty-six hours.

Autopsy.—Forty-eight hours after injection. Rigor mortis marked. Pleurisy slight; some fibrin in the left side at point where needle entered the lung. Peritonitis very marked with sero-fibrinous exudate; brownish serum in bottom peritoneal cavity. Cultures from peritoneum and pleura, pure culture diplococcus pneumoniæ.

9. Small, active rabbit, injected with pure culture diplococcus pneumoniæ obtained from animal 8.

Autopsy made before rigor mortis. Pleurisy marked; sero-fibrinous exudate on both sides. Pericarditis with adhesions; sero-fibrinous exudate. Spleen large. Peritonitis marked; sero-fibrinous exudate. Pure cultures of diplococcus pneumoniæ obtained from pleura, pericardium and blood.

10. Rabbit, medium-sized animal, injected with peritoneal fluid of animal 9; died in two days.

Autopsy.—Four hours post mortem. Pleurisy left sero-fibrinous. Pericarditis slight. Peritonitis marked. Spleen enlarged. Cultures show diplococcus pneumoniæ.

11. Rabbit, large white doe, injected with twenty minims of peritoneal fluid of rabbit 10, in each lung ten minims; killed by medulla on seventh day in dying condition.

Autopsy.—Marked sero-fibrinous pleurisy on both sides and also pericarditis. Spleen large.

12. Rabbit, small-sized, lively animal; injected with peritoneal fluid of rabbit 8; first two days considerable dyspnœa, but recovered and was apparently well. Killed after a week; the only thing found were a few delicate adhesions between the coils of intestine; some clear fluid in bottom of peritoneal cavity.

13. Rabbit, medium-sized; pure culture injection; killed after fifth day.

Autopsy showed marked sero-fibrinous pleurisy; marked sero-fibrinous pericarditis, also advanced peritonitis, with sero-fibrinous exudate. Large spleen. Pure culture of diplococci obtained from blood, pleuritic and pericardial fluid.

14. Rabbit; died with a paralysis of posterior extremities; exhaustion; remains of an old pleurisy found; adhesions of the costal and pulmonary pleuræ. This animal was injected in the pleura with pure culture streptococcus pyogenes.

15. Rabbit; injected with pure culture streptococcus pyogenes in pleural cavity from Case XI.; died after two days.

Autopsy.—Kidneys larger than normal and congested, but the spleen was enormous in size. Cultures of blood gave streptococci.

16. Rabbit; subcutaneous injection streptococcus pyogenes (pure); death after three days.

Autopsy.—Jaundice, universal, of all tissues. Lungs contained small abscess in lower right lobe. Heart, normal. Liver, very small abscesses, studded throughout. Kidneys, cloudy swelling. Spleen much enlarged. Urine, bile pigment.

17. Rabbit; injected with pure culture streptococcus pyogenes, with no result; lived for months.

In addition to the above experiments, there were some injections into guinea-pigs of the diplococcus pneumoniæ; these resulted negatively, except one animal which had been injected with pleuritic fluid from a rabbit that had died in its turn from an injection of diplococcus. In this there were typical pleurisy, pericarditis, and peritonitis, with large spleen.

A few injections upon rats and mice subcutaneously resulted in case of diplococcus positively in one case. Injections into additional rabbits with pus obtained from a tubercular case gave nothing worthy of note.

Cases.

Case I.—Y. S., aged seven years, admitted into hospital. Mother has had phthisis; child has had measles, four years ago, since then a slight cough. Became sick suddenly two weeks ago; has been ill since with cough, pain in the side, chilly sensations, dyspnœa.

Physical signs (left side). Flatness from mid-scapula down. Bronchial voice and breathing (at middle scapula), below distant breathing. Signs of bronchitis on both sides; no signs of phthisis in front or on opposite side.

Operation eighth rib, resected in the post-axillary line; abscess was found to be higher up and encapsulated; adhesions had to be broken down in order to reach empyema. Examination of pus: crude cover and cultivation; streptococcus pyogenes. Cured.

Case II.—R. T., male, aged eight years; January 1st. Family history negative. He had scarlet fever four years ago; a year ago had a bronchitis; a month ago also bronchitis (?). Two weeks ago had fever, temperature 104° (physician). Complained of headache; next day had pain in the left side; dyspnœa; slight cough; no expectoration; temperature 103°. During the next week the temperature did not exceed 101.5°.

Admission to hospital showed marked œdema of skin of left side, but on incision later (at operation) no infiltration of pus was seen; signs of fluid in left side.

January 2. Operation, resection as noted; there was no infiltration of the œdematous skin with pus. In spite of resection the lung would not expand.

January 3 *to February* 10. Temperature 100°, 101°, to 104°; pulse 110, 112, 138, to 152; respiration 32, 44, to 52. The boy did badly; there was a profuse discharge of pus, fœtid in odor at each dressing, and lung did not expand. Several resections were performed upon this chest

to favor retraction of chest toward lung and closure of the large cavity in the chest. There resulted much deformity, and at discharge from hospital there existed a discharging fistula in the chest.

Bacterioscopic results were limited to stainings of cover-glass specimens of pus and showed tubercle bacilli. Animal experiments negative.

Case III.—I. S., aged two years; male; February 18, 1890. Has had measles, a year ago; inflammation (?) of the lungs ten months ago; present illness began with fever six weeks ago; this fever after a few days was complicated by convulsions recurring at intervals. Cough was very marked and present during the entire illness; there was loss of flesh and strength, and increasing palor.

Admission to hospital showed a weakly child, badly nourished, pale; temperature 100°; respirations 40; pulse 120. Physical signs of fluid in right side chest. Tenth rib exsected; about a pint of thick, green, tenacious pus evacuated.

Bacterioscopic result of examination, pus; diplococcus pneumoniæ (Fränkel and Weichselbaum).

May 11. Discharged cured.

Case IV.—I. S., male, aged eleven months; has been sick for three weeks with fever, cough, dyspnœa, emaciation. Signs of fluid in right pleural cavity. Dulness to flatness. Loss of movement. Loss of fremitus. Loss of voice; pleuritic râles over whole side; syringeful yellow, thick pus removed.

Bacterioscopic examination. Staphylococcus pyogenes aureus. Result unknown.

Case V.—P. M., male, aged two and a half years; March 3, 1890. Previous history negative. Present illness began a month ago with fever, cough, difficulty in breathing, and constitutional disturbances; fever continued marked during the first two weeks, then abated, but continued nevertheless; palor, loss of flesh and strength, and generally becoming worse.

Admission to hospital. Anæmic, poorly nourished, anorexia, cough, prostration, and fever; temperature 101°; respirations 46; pulse 140. Signs of fluid in the left side and areas of consolidation (broncho-pneumonia) over the right side. Heart apex just inside the middle line.

March 4. Turbid flocculent serum removed from the chest. Cultures show diplococcus pneumoniæ. Aspiration, only four fluidounces (serous) removed in all, but patient continued to grow worse, temperature varying from 101° to 104°; respirations from 50 to 70; pulse 148 to 160.

16*th*. Needle in left side withdrew a creamy pus.

18*th*. Resection of rib, and about one ounce of pus evacuated, but patient grew worse; died March 27th from broncho-pneumonia on both sides.

Examination (bacterioscopic) of pus withdrawn March 16th, showed diplococcus pneumoniæ.

Case VI.—I. K., male, aged three and a half years; March 13, 1890. Family and personal history not lucid. Present illness began nine weeks ago with fever and cough and difficulty in breathing; prostration, loss of appetite; patient complained of pain in the left side; loss of flesh and strength; there were night-sweats; patient has steadily lost ground.

Admission to hospital. Poorly nourished, anæmic, delicately built lad; no sign of rhachitis; temperature 101°; respirations 40; pulse 132 (dyspnœa). Physical signs showed fluid in left side. Heart apex

pushed to the right, and most intense behind lower end of sternum; no signs of phthisis at apices.

March 16. Operated resection of eighth rib; greenish odorless pus, with large masses of fibrin evacuated, as big as a child's hand.

28*th*. Discharged cured.

Bacterioscopic examination of pus, diplococcus pneumoniæ.

Case VII.—M. B., aged two years; male; March 1, 1890. Family and personal history negative. The previous history is indefinite; the patient for some time has suffered from cough. Present illness dates a week back; contracted a severe cough, and dyspnœa became very marked; fever, night-sweats, loss of appetite.

On admission, patient is well nourished; suffers great dyspnœa, this symptom so marked as to give impression that œdema of the glottis was present, or obstruction in the larynx. Intubation attempted but failed, and tracheotomy performed. Temperature 100°. Examination of the chest revealed spots of broncho-pneumonia over both sides. March 5th to 15th, temperature 101° to 105°; respiration 40 to 76; pulse 140, with dyspnœa; increasing; attempts to remove tracheal tube resulted in renewed attacks of dyspnœa. March 15th, signs of fluid in left side of chest, and on March 16th, operated, and twelve ounces of pus, greenish, no bad odor, removed from left side. Eighth rib resected.

March 18. Discharged cured.

Results: Bacterioscopic study and culture of pus. Diplococcus pneumoniæ.

Case VIII.—H. G., male, aged twelve years. Father, mother, and sisters and brothers in good health; previous history indefinite. It is not possible to obtain definite information as to the exact time of onset of present illness. He has for a few weeks past suffered from cough, fever, and night-sweats, pain in the right side upon coughing or taking deep inspiration; has been confined to his bed; no history of traumatism.

Admission to hospital. An anæmic but well-built lad, not at all emaciated. Physical examination reveals fluid, and needle pus in right side. Temperature 100°; respiration 40; pulse 140; resection of rib on right side and a pint of greenish fluid, not adhesive pus, removed; no fibrin clots were withdrawn; some adhesions between the costal and pulmonary pleuræ.

Bacterioscopic examination of pus revealed streptococcus pyogenes.

Result: Cure.

Case IX.—Female, aged two and one-fourth years. April 10, 1890. Family history shows nothing. Present illness began three weeks ago with some eruption (?) upon the body; about a week later there appeared a cough, fever, distress in stomach and abdomen.

Admission to hospital. Anæmic child, with signs of rhachitis, cough dyspnœa, and some cyanosis; temperature 101°; pulse 160; repirations 48. Physical signs of fluid in the right side, pus withdrawn, immediate operation, exsection; sixteen ounces of pus evacuated. April 12th to 22d, temperature varied from 99° to 103°; respirations 40 to 43; pulse 130 to 158; but April 22d, symptoms pointing to an invasion of the healthy lung by broncho-pneumonia appeared, and patient died with all the symptoms of pneumonia and exhaustion.

Bacterioscopic examination of pus revealed diplococcus pneumoniæ (Fränkel and Weichselbaum).

Case X.—M. G., male, aged four years; April 18th. Family and

previous history negative. Present illness began seven weeks ago with scarlet fever; three weeks later the patient developed general anasarca, this lasted until eight days ago; at the same time he had a severe cough, chills, and fever; constant sweating, lasting until the date of admission; loss of flesh and strength, also failure of appetite and frequent micturition.

Admission to hospital. Patient anæmic and emaciated, cough and dyspnœa. Temperature 99°; respirations 42, and pulse 140. Signs of fluid in the left side. Heart apex pushed to the right of the sternum.

Operation, exsection of rib; twenty-nine and a half ounces of pus of creamy character evacuated.

Bacterioscopic examination revealed diplococcus pneumoniæ.

Result: recovery.

Case XI.—Male child, aged four months. May 9, 1890. Had been perfectly well until two weeks ago, at this time child was vaccinated; simultaneously with the vaccination, there appeared a burrowing abscess on the dorsum of the left foot which was deep and passed between the metatarsal bones. Eight days ago a febrile movement appeared and the patient was referred by me to a surgeon for treatment. There were at this time no lung symptoms. Three days ago the child developed cough and dyspnœa.

Status: There is cough, dyspnœa, sighing respiration; pulse increased in rapidity; temperature 103°; abscess on foot still present; vaccine pustule still size of five cent piece and angry-looking. Examination of left side revealed chest full of fluid and needle withdrew pus, light yellow, thin, easily separating into two layers, clear and serous, upper and lower purulent.

May 10. Exsection of rib; six ounces of pus (milky) evacuated.

12*th*. Died; no autopsy.

Bacterioscopic examination of pus revealed streptococcus pyogenes.

Case XII.—*May*, 1890. Male, aged twelve months; well developed; has been suffering from pertussis and just recovered; about two weeks before date was doing well, when suddenly there appeared a new cough with dyspnœa, and broncho-pneumonia of the right lung was diagnosticated. The cough and fever and dyspnœa still continued up to May 9th, when fluid was found in the right side. A needle introduced about this time withdrew a clear serum; temperature 103°; pulse 160, and rapid respiration. Transferred to the hospital, where child next day showed a measles eruption.

13*th*. Needle introduced into right side and pus was withdrawn; child was doing well, but on the morning of the above date, patient suddenly developed tympanites (peritonitis (?)) and died.

Bacterioscopic examination of pus of May 13th and serum of May 9th revealed diplococcus pneumoniæ.

Case XIII.—Empyema; perforation; spontaneous recovery. Female, aged thirteen months. May 12, 1890. Previous history negative. Child was taken ill about three weeks ago with cough, fever, dyspnœa. The child had dyspnœa, and moaned when it breathed; there was a frequent cough and a temperature of 103½°; pulse 160. Examination of chest showed consolidation of the left upper lobe (dulness, bronchial voice and breathing). Diagnosis: broncho-pnumonia. The patient seemed to improve up to a week ago, when the temperature and cough persisted, the dulness behind became more marked and spread toward the base

of the lung; fremitus absent; voice and breathing bronchial. Needle introduced and pus withdrawn from left side, greenish-yellow, adhesive; heart not displaced; operation advised.

August 1. Child had escaped from observation, and having refused operation passed under care of others. It was brought to me, August 1st, for diarrhœal trouble; chest showed no signs of old trouble; lung had expanded; voice and breathing good, no friction sounds. There was a slight dulness only left over the affected side; fremitus good; no fever; child looks much improved. Mother says that after leaving my care the patient grew worse until she began to cough up large amounts of yellow matter (pus?). This continued some time at intervals; patient recovered; no cough.

Bacterioscopic examination of pus May 12th: diplococcus pneumoniæ.

Case XIV.—*May* 13, 1890. L. H., aged eighteen months, male; previous history negative; father and mother well and in apparent good health. Nine days ago child developed a cough, fever and dyspnœa; the dyspnœa increased, fever continued and there was restlessness at night. When brought to me the child was anæmic; had signs of rhachitis; there was much dyspnœa and moaning respiration, drowsiness, and partial stupor. Temperature 105°; pulse 165; respirations 56. Physical signs of fluid in right side below mid-scapula, needle introduced and removed, a clear bloody serum obtained.

14*th*. Needle introduced, signs of fluid having increased, and withdrew milky pus.

15*th*. Exsection of rib, eight ounces of pus removed.

Bacterioscopic examination showed staphylococcus pyogenes aureus.

Case XV.—D. H., male, aged five and a half years. Father and mother living, has had no special illness; present illness dates from October 6th, when there was fever and pain and dyspnœa; the pain was referred to the stomach; there was no distinct history of chill. When first seen, October 7th, patient was a well-developed child; no signs of past rhachitis; there was dyspnœa, a dry cough, fever; there was also some restlessness; complains of stomach pain. Temperature 103°; pulse 130; respirations increased. Signs in chest negative.

October 8. Temperature 104°; pulse 140; respirations rapid; pain in right side; rusty sputum. Diagnosis at this time; right lobar pneumonia lower lobe. At end of five days signs pointed to a resolution of an ordinary lobar pneumonia; temperature 102°.

19*th*. Signs of fluid in chest. The boy has not been doing well, and new signs appeared; loss of fremitus; flatness, bulging of right side; subcrepitant râles close to the ear, voice and breathing though coarse heard over whole chest; dyspnœa great; temperature 103½°; pulse 160; respirations rapid.

21*st*. Operation: simple opening in chest and tube inserted; about half a pint of pus evacuated; not fœtid; yellow color.

27*th*. Discharge fœtid and penetrating odor; the drainage bad and a resection was performed, November 5th. Final complete recovery.

Bacterioscopic examination of pus first taken from chest showed diplococcus pneumoniæ.

Clinical Classification.

The cases here recorded, from a clinical and bacteriological standpoint, divide themselves quite readily into groups.

Group I.—Here we can place those cases of empyema in which the bacterioscopic examination revealed the staphylococcus pyogenes aureus, or the streptococcus pyogenes. These microorganisms did not exist associated, but in so-called pure form and isolated in the exudate. The etiology of these cases is very difficult to make out, because this group does not include cases of empyema where an extraneous source of infection exists. Those cases of empyema in which the pleuritic exudate shows simply the presence of the staphylococcus or streptococcus alone, and where there is no history of traumatism with perforation of the skin, or where there is no suppurating focus of infection outside the pleural cavity, are most puzzling to explain because the bacterioscopic finding gives us no clue as to the origin of the disease. The staphylococcus and streptococci are microörganisms which exist in suppurating processes of the most diverse nature and situation in the body. I have four such cases to place under this heading. One female, aged seven years, and three male children, aged eighteen months, two years and twelve years respectively. In none of these cases was there a history of traumatism of any kind. When they came under observation, they had been ill with symptoms of pulmonary trouble for periods varying from one to six weeks.

Assuming that an infection of the pleura is most apt to result from adjacent inflammatory processes, the most usual disease preceding or complicating such a pleurisy is pneumonia. Weichselbaum has demonstrated that in addition to the pneumococcus of Fränkel, there exists in the lungs of pneumonic patients the streptococcus pneumoniæ (or pyogenes) and the staphylococcus pyogenes aureus. Though we cannot as yet yield to these microörganisms the dignified position of being the direct cause of pneumonia, we find that they exist in the lung constantly as so-called mixed infections, as they do in diphtheria. Thu[1] has argued that microörganisms in pneumonic fibrinous pleuritis and pericarditis (pneumococci) first find their way through the lymph channels into the subpleural tissue and then into pulmonary pleura, and finally gain the surface of the pulmonary and costal pleura; from thence they may be carried into the mediastinal spaces and reach the tissue of the pericardium and even the muscular tissue overlying the costal pleura. It is true that the failure to find the pneumococcus in the exudate does not disprove the possibility that at some early stage of the empyema it might have been present; however the tendency to-day is to consider the active

[1] Centralbl. f. bakteriol., 1889, Bd. v.

predisposing causes exposure to cold and moisture. It is thought that though the above microörganisms may exist in the air passages, as has been proven in the nose and mouth of a healthy individual, they may remain inert until, cold and wet reducing the resistant vitality of the organism, they cause an empyema; so a wound in the chest wall without perforation of the skin may exert a similar influence.

Group II.—The cases of empyema which fall under this group are the most interesting of all pleurisies. They are those which either complicate or follow a pneumonia. In the pleuritic exudate of such an empyema the diplococcus pneumoniæ (Fränkel and Weichselbaum) may be demonstrated as in all of my cases.

These were two female children, aged thirteen months, and two and a quarter years, respectively, and seven male children aged twelve months, two years, two two and a half years, three and a half years, four years, and five and a half years. They had been ill when they came under observation for periods ranging from one to nine weeks. In one case the patient had been under the observation, from the very beginning, of a skilful observer (Case XV.), and the diagnosis of lobar pneumonia followed by a pleurisy (empyema) was distinctly traced. As recorded elsewhere, the diplococcus pneumoniæ (Fränkel) could be easily recognized in the crude pus by spreading upon cover-glass; beautiful capsule appearances were also obtained. Pure cultures were isolated in every case and their virulence tested upon animals while the cultures were still recent. The experiments were in the direction of intra-pleural or pulmonary injections, so that appearances in the animal experiments resembled very much what is seen in the human subject. If such a pathogenic microörganism is found in a pleuritic exudate, it can be traced to only one probable source, the lung. It is scarcely necessary in any of these cases to prove clinically the existence of a pneumonia. If one will refer to the histories of the cases he will see that in some a pneumonia, either of the lobar or lobular type, must have been in active progress when the empyema was operated upon. At least the physical signs and symptoms indicated this condition of affairs in the lungs upon the opposite side to the empyema, if not in the lung corresponding to the empyema.

In one case, where the patient succumbed, the opposite lung was undoubtedly affected. In other cases, after operation, the temperature would not only persist, but persistent broncho-pneumonic processes were present; this was notably the history of Case III., who continued in the hospital for months, being finally discharged cured. In these cases, tuberculosis was excluded by all possible methods, both clinical and bacteriological. But in the majority of the cases in which the pneumococcus was found in the pus of the empyema, the evacuation of the pus

marked the retrograde of all symptoms and recovery of the patient, showing that the pneumonia, if it existed, had preceded the accumulation in the chest and had passed through its various stages. The pneumococcus has been found by Weichselbaum in lungs the seat of lobular pneumonia, as well as in those the seat of lobar process.

I have elsewhere described the macroscopic characters of the pleural exudates in the cases of empyema belonging to this group. But in two the pleuritic fluid when first withdrawn from the chest was serous in character, in one case even devoid of flocculi. In both of these cases, the exudate taken later with an exploring syringe was markedly purulent, and both cases were operated upon. In the serous fluids first obtained, as also in the purulent exudate, the diplococcus was found. This shows distinctly that though an exudate may be serous at first, it may subsequently become markedly purulent, not on account of anything introduced into the chest on the occasion of the first puncture, but from the continued action of microörganisms already present (diplococcus pnemoniæ or streptococcus pyogenes, Fränkel). Again, pus in the chest has a tendency, without this cavity, to separate into strata, the upper one being serous and containing but few leucocytes; we may aspirate this stratum in a marked empyema, and thus can not draw any definite conclusion as to the nature of the exudate. If an exudate contain streptococci, even though serous, we can with certainty predict the advent of pus (Fränkel). We might make a similar assertion of fluids containing the diplococcus pneumoniæ. If a serous fluid withdrawn from the chest fails to reveal any microörganisms upon stain or culture, we can conclude that there is a probable tubercular element in the pleurisy (Fränkel). If such a serous exudate subsequently shows the presence of microörganisms (streptococci) and then becomes purulent, we can suspect contamination. With conscientious cleansing of a needle-syringe, we may fearlessly enter the pleural cavity without having in the least compromised the health of the patient. I am certain much misunderstanding has arisen on this subject through a misinterpretation of the real nature of some of these serous exudates. While some are devoid of microörganisms (tubercular), others are filled with pyogenic microbes, capable not only of producing suppuration, but maintaining it.

Group III.—This group, which includes empyema of tubercular nature, is most unsatisfactory in its various aspects. Fränkel, who spent much time and patience upon tubercular pleurisies in the adult, found cases in which examination of the exudate yielded a negative result. So common was this, that he concluded that a negative finding was much in favor of the tubercular character of the exudate. These exudates may be localized or involve the whole pleura. They may or may not be accompanied by lung areas of tuberculosis; in cases where the lung is involved, in the adult, the tubercle bacilli may be found in the sputum,

but in children the examination of the sputum is not always practicable. If, as in children, the lung shows no positive involvement and the examination of the exudate is negative, diagnosis and prognosis are difficult. Ehrlich (*Charité Annals*, 1888) explains the absence of tubercle bacilli in two ways: 1. The fibrin formations in the exudate remove the bacilli by enclosing them. 2. Thickening of the pleura by adhesions causes a resistance to the transmigration of bacilli. In empyema, the bacilli are more numerous than in simple pleuritic exudates, because cells passing in myriads into the exudate are more apt to carry bacilli with them. Israel and Gerhart think that the bacilli rather become entrapped in the miliary growths of the pleura, and thus do not pass into the exudate.

I have but one case to place in this group, that of Case II., a boy of eight years, who had had several bronchitic attacks years before the advent of his empyema. The exudate had to be repeatedly examined in order to establish the presence of tubercle bacilli (stained by Ehrlich's method), but the experiments with animals were of a negative character. In this case the streptococcus pyogenes was also found in the exudate from the very first; this is similar to a case in the adult recorded by Fränkel. The formation of adhesions tying down the lung must have been exceedingly great, for operation found the lung unable to expand and repeated exsection of the rib had to be resorted to, in order to obtain partial closure of an immense suppurating cavity. The deformity resulting was most pronounced. I have made attempts in other children and this boy to obtain sputa for examination, but have not succeeded. I attributed my ill success in inoculation upon animals to the presence of contamination in the pus.

Thus, my group of tubercular empyema remains unsatisfactory, though diagnosticated with a certainty from the presence of tubercle bacilli in the exudate. The lungs upon examination yielded no evidences of involvement.

Group IV.—In this group we might class those cases of empyema in which some focus of suppuration situated in another part of the body may be with great probability pointed to as a source of infection. The infecting focus may be adjacent, as in the cases of Fränkel, where a retro-pharyngeal abscess or perforating peritonitis were the cause of the empyema, or the empyema may be one of the manifestations of a species of pyæmia (as in my own case). This was a male infant, aged four months, who was perfectly well up to within two weeks of its death. The infant was vaccinated and then developed a burrowing abscess of the foot, and after this the empyema appeared. No autopsy was allowed; it would have been interesting to see (though no pneumococcus was found in the exudate of the pleura) whether a pneumonia (pyæmic) was present with the empyema. The rapid death of the

child speaks in favor of some virulent infection; an autopsy might have revealed several other hidden foci of suppuration.

The bacterioscopic finding and experiments in the above case are interesting. The streptococcus which was isolated and existed alone in the exudate was certainly very virulent. Two animals injected with a pure culture (15 and 16), both died. Both were injected at the same time with the same culture; the one in the pleural cavity, in this case, the animal died in two days; streptococci were found in the blood and organs, but there were no inflammatory exudates; the kidneys were swollen and the spleen was enormous in size. The second animal was injected subcutaneously, and the report of autopsy shows metastatic abscesses all over the body with general jaundice and enlarged spleen and cloudy kidneys. These results differ widely from those with streptococci obtained from cases of Group I. Here the animals survived and autopsies after months showed no effects of infection, or as in rabbit 14, only the effects of local processes limited in nature.

Putrid Empyema.

By this, I desire to designate those cases of empyema in which there was a putrid or fœtid odor to the discharge, and in which this odor persisted.

In both of my cases the exudate turned putrid after operation. In one (XV.) the empyema followed a pneumonia, and in the fluid first withdrawn from the chest, the pneumococcus alone existed. In this case, on account of the imperfection of drainage due to the first mode of operating, there was retention of pus, the chest wound finally closed, and when reopened again for resection, the pus was very putrid.

The second case was that in which the pus showed the presence of tubercle bacilli. There was no odor to the pus upon the first resection. But there was not only lack of any expansion in the lung, leaving an immense cavity in the chest, but the pus remained in this cavity. Here the emyema became putrid, necessitating repeated washings of the chest with creolin solution. In spite of this fact, the pus remained putrid. Investigation succeeded in revealing the presence of a florescent green bacillus, rather thick and short, which fluidified gelatin (much like that found in water) and grew upon agar of Weichselbaum in a dark-green layer with a rather mawkish odor to the growth. This is all that could be found in addition to the tubercle bacillus and streptococcus previously present. This shows that the most innocent exudate may turn putrid, as in the case of pneumonic empyema, as well as the tubercular cases. It seems rational to suppose that lack of expansion of the lung or retention of pus, especially where the chest has been injected with so-called antiseptic solutions (in the above cases boric acid or creolin), are conditions peculiarly

favorable to the development of putrid exudates. I have seen air enter daily freely into the chest cavity without causing the pus to become putrid; also the introduction of bacteria from the lips of the wound was unavoidable, on account of the free moving of drainage-tubes and dressings and tampons over the mouth of the external wound. Yet drainage being free, with full lung expansion, no putridity appeared. In the future, the appearance of a putrid exudate in a chest in which primarily the pus possessed no such characters, would make me think of retention due either to insufficient drainage or want of proper expansion of the lung.

PROGNOSIS.—We can safely say that the present status of our knowledge in these cases enables us to assure our patients with moderate certainty as to the outcome of the illness of their children. Such prognosis may be made at the bedside or within a very short period from the first examination of a case. The simple means at the disposal of every clinician are adequate for the examination of crude specimens of pus, and delay of a day or two at the most is all that may be necessary for more deliberate investigation. Nor do I think that we should take too much credit to ourselves for the recovery of a certain class of these cases which, under proper guidance, invariably get well. Thus, it would appear that the best prognosis is held out to those which belong to Groups I. and II. More especially is this true of cases of meta-pneumonic empyema. In one of these (XIII.), in which the purulent exudate filled the chest and was withdrawn from the same by exploring needle and contained pneumococci, the patient recovered; having refused operation, the empyema perforated the lung and thus gained exit externally, pus being coughed up. Subsequent examination of this case revealed nothing abnormal on the diseased side but slight dulness. The lung had thoroughly expanded. Fränkel records similar cases in the adult. It would scarcely be well to expect too much from such "laissez faire" treatment, for a large percentage (Ziemssen's *Vorträge*) of cases which are allowed to perforate die. The age of the patient and the presence or absence of any considerable pneumonia will weigh in each case. Some authors are enthusiasts for the simple opening and drain in the chest; others insist on the trial of repeated aspiration; others contend that resection of the rib is the only safety of the patient and secures a rapid expansion of the lung. The truth lies in the etiology of the cases of empyema. In the meta-pneumonic exudates cases will do equally well by the various modes of treatment; in other words, the pus evacuated by whatever means, there is an inherent tendency to absorption of what inflammatory product there is remaining and return to a normal status, as in the pneumonic lung.

The pneumonic exudates, if they hold out such brilliant prospect of recovery to the patient, are a striking contrast to the tubercular cases,

where only a partial recovery is at best possible. There are cases on record where, especially in children, an empyema (Ziemssen's *Vorträge*) of established tubercular nature has made an apparent good recovery, yet we must doubt its permanency. We cannot rid ourselves of the idea that a large extent of surface like the pleura, once tubercular, must, if recovery takes place, be a latent danger to the patient.[1] In other cases, the recovery results with fistulæ, retraction and all the concomitants of permanently crippled respiratory apparatus. The pyæmic cases are fatal, as far as we know.[2]

[1] Klesch and Vaillard (Arch. de Physiol. et Path., 1886) have made autopsies upon pleurisies of a tubercular character which had apparently recovered, and were able to prove their tubercular nature at autopsy.

[2] I desire to express my sincere obligations to Dr. Barium Scharlau, of the Mount Sinai Hospital, for the clinical material which he so kindly placed at my disposal.